Southwick Rodgers Bedrock Compilation Sheet 3 (paper)

Map

NOTICE !

Bedrock quadrangle 1:24,000 scale compilation sheets for the Bedrock Geological Map of Connecticut, John Rodgers, 1985, Connecticut Geological and Natural History Survey, Department of Environmental Protection, Hartford, Connecticut, in Cooperation with the U.S. Geological Survey, 1:125,000 scale, 2 sheets. [minimum 116 paper quad compilations with mylar overlays constituting the master file set for geologic lines and units compiled to the State map, some quads have multiple sheets depicting iterations of mapping]. Compilations drafted by Nancy Davis, Craig Dietsch, and Nat Gibbons under the direction of John Rodgers.

Geologic unit designation table translates earlier map unit nomenclature to the units ultimately used in the State publication.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

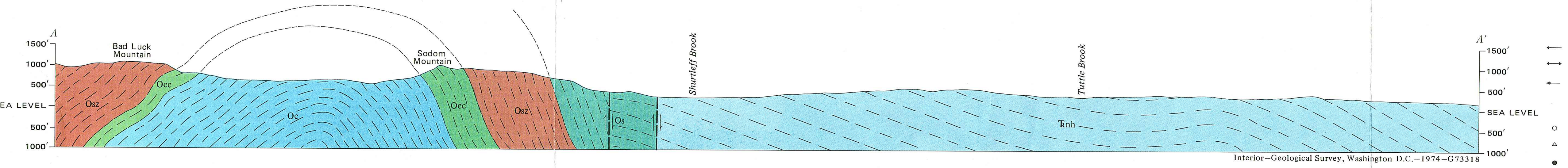
Prepared in cooperation with the
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS
and the
STATE OF CONNECTICUT
GEOLOGICAL AND NATURAL HISTORY SURVEY

Base from U.S. Geological Survey, 1958
10,000-foot grids based on Massachusetts coordinate system, mainland zone, and Connecticut coordinate system
1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

Geology by R. W. Schnabel, 1961-63; assisted by Curt Dechert, 1961, and by R. L. Kroll, 1962-63



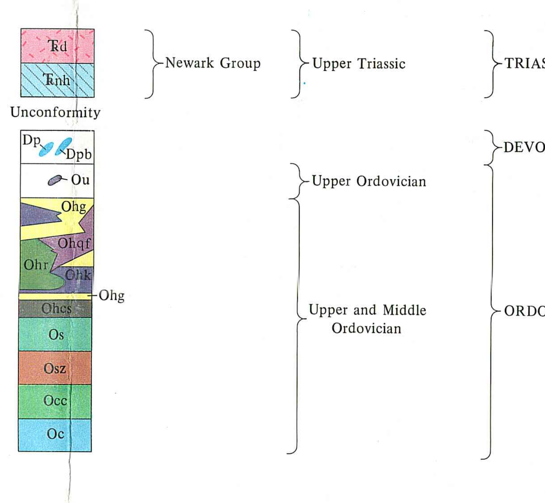
Interior—Geological Survey, Washington D.C.—1974—G73319

BEDROCK GEOLOGIC MAP OF THE SOUTHWICK QUADRANGLE, MASSACHUSETTS AND CONNECTICUT

By
Robert W. Schnabel
1974

6

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

In the following descriptions, mineral names are arranged in order of decreasing abundance. Minerals found in some, but not all, outcrops are in parentheses

Td DIABASE (UPPER TRIASSIC) – Medium- to dark-greenish-gray, fine- to medium-grained plagioclase-augite-chlorite-magnetite-pigeonite-devitrified glass-quartz diabase. Exposed only on two small hills in southeast corner of quadrangle. Mapped area extended eastward on the basis of angular fragments in surficial deposits on Copper Hill Road

Tnh (st, s, c) NEW HAVEN ARKOSE (UPPER TRIASSIC) – Predominantly moderate-reddish-brown, locally moderate gray, light-reddish-brown and yellowish-brown, fine- to very coarse-grained arkosic siltstone (st), sandstone (s), and conglomerate (c). Approximately 5,000 feet of lower part of the formation present in eastern part of quadrangle

Dp PEGMATITE (DEVONIAN?) – Light-yellowish-gray, very light gray, and light-pinkish-gray, coarse- to extremely coarse-grained quartz-plagioclase-(microcline)-(muscovite)-(biotite)-(garnet)-(tourmaline)-(beryl) pegmatite. Individual bodies range from a few inches to about 1,500 feet in maximum dimension in a given exposure. No attempt was made to correlate bodies across areas of nonexposure. Bodies are highly irregular both in plan and in cross section, and are both concordant and discordant. Nearly all outcrops in the area composed of pre-Triassic rocks contain one or more pegmatite bodies

Dpb Pegmatite containing trace amounts of beryl – Found in northwest part of quadrangle, on Gorge Road, west of Rocky Point

Ou ULTRAMAFIC ROCKS (UPPER ORDOVICIAN) – Dark-greenish-gray to yellowish-gray, medium- to coarse-grained serpentinite and talc rock in boulders, possibly representing outcrop located in the north-central part of the crystalline rocks, and on the southeast flank of Drake Mountain. Till along the crest of Drake and Sodom Mountains contains abundant angular boulders of ultramafic rock

HARTLAND FORMATION (UPPER AND MIDDLE ORDOVICIAN):

Ohg Garnet schist – Medium-gray, coarse-grained quartz-plagioclase-biotite-muscovite-garnet-(sillimanite)-(kyanite)-tourmaline-(apatite)-magnetite schist. Characterized by brown euhedral garnets ¼ to ½ inch in diameter and by lenticles of granular quartz averaging about ½ inch thick and 1 foot long. Very poorly bedded, with indistinct layering marked by local increases in abundance of individual minerals. In three layers totaling about 2,000 feet in thickness

Ohk Kyanite-sillimanite schist – Medium- to dark-gray, locally rust-stained, coarse- to very coarse-grained quartz-plagioclase-biotite-muscovite-(kyanite)-(sillimanite)-garnet-(staurolite)-apatite-tourmaline-magnetite schist. Locally contains kyanite crystals as much as 6 inches long. Very poorly bedded, with indistinct layering marked by local increases in abundance of individual minerals. In two layers: upper is about 500 feet thick; lower is about 500 to about 2,000 feet thick

Ohqf Quartz-plagioclase mica schist – Medium-gray, locally rust-stained, fine- to medium-grained quartz-plagioclase-biotite-muscovite-garnet-(tourmaline)-(sillimanite) granular schist. Characteristically a well-bedded rock containing quartz-feldspar layers averaging about 2 inches in thickness, separated by mica-rich layers 1/8 to 1 inch in thickness. 0 to about 1,000 feet thick

Ohr Rusty mica schist – Medium-grayish-brown, deeply rust stained, muscovite-biotite-quartz-plagioclase-garnet schist. Abundance of mica and rust staining are characteristic. Poorly exposed, bedding not developed on scale of outcrops. 0 to about 1,000 feet thick

Ohcs Calc-silicate zone – Dominantly brownish-gray to medium-gray, medium-grained quartz-plagioclase-muscovite-biotite schist. Zone characterized by subordinate layers and lenses of light-greenish-gray quartz-plagioclase-clinozoisite-epidote-microcline-calcite rock and by thin lenses and beds of hornblende-biotite-garnet-(plagioclase) amphibolite. Bedding is rarely preserved in the schists, locally the calc-silicate rocks and amphibolites are thinly laminated. Layers of calc-silicate rock and amphibolite are parallel to schistosity in the schist. Averages about 100 feet thick

STRAITS SCHIST (UPPER AND MIDDLE ORDOVICIAN):

Os Upper schist – Medium-brownish-gray, medium-grained quartz-plagioclase-biotite-muscovite-garnet-(kyanite)-(sillimanite)-(staurolite)-(tourmaline)-graphite-apatite-opaque minerals schist. Locally contains sparse small lenses or pods of zoisite-bearing amphibolite typical of underlying unit. Very well bedded in upper part having graded beds ½ inch to 1 foot thick, becomes less well bedded toward base. Averages about 2,000 feet in thickness

Osz Zoisite zone – Matrix is identical to lower part of upper schist, but this zone is characterized by abundant pods or lenses of dark-gray, medium- to coarse-grained quartz-plagioclase-hornblende-diopside-tremolite-garnet-zoisite-sphene amphibolite, containing zoisite porphyroblasts locally as much as 2 inches long. Bedding is poorly developed throughout this unit. Ranges in thickness from about 400 feet to about 2,000 feet

COLLINSVILLE FORMATION OF STANLEY (1964) (UPPER AND MIDDLE ORDOVICIAN):

Occ Coticule zone – Medium-brownish-gray, medium-grained quartz-plagioclase-muscovite-biotite-(kyanite)-(sillimanite)-(staurolite)-(tourmaline)-(apatite)-opaque minerals schist, containing beds 1/8 to 4 inches thick of light-pink to light-pinkish-gray, fine- to very fine-grained quartz-garnet granofels (coticule). Zone is characterized both by absence of graphite and by presence of coticule layers. Beds are sparse in the schist, coticule layers are interpreted to be beds. Ranges in thickness from about 200 to about 1,000 feet

Oc Heterogeneous layered sequence of amphibolites, granitic gneisses, schists, and coticules – Characterized by beds 1 to 4 feet thick of very dark gray to black, medium- to coarse-grained hornblende-plagioclase-quartz-(biotite)-(sphene)-(garnet)-(pyrite) amphibolites that are commonly internally well layered. Includes layers as much as 20 feet thick of light-gray to medium-yellowish-gray, medium- to coarse-grained quartz-plagioclase-biotite-muscovite-(garnet) gneisses, that seem to become more abundant toward the base; 1- to 4-foot-thick layers of reddish-brown to brownish-gray (rusty to nonrusty weathering) medium- to coarse-grained muscovite-biotite-quartz-plagioclase-(garnet) schists, that are most abundant toward the top; and ½-6-inch-thick layers of moderate-pinkish-gray quartz-garnet-(muscovite)-(biotite) granofels (coticule). Minimum thickness is about 1,500 feet; base is not exposed

BEDROCK OUTCROPS – Solid red overprint indicates individual outcrops; ruled pattern indicates areas of closely spaced small outcrops

CONTACT – Dashed where approximately located

NORMAL FAULT – Dashed where approximately located. U, upthrown side; D, downthrown side

SMALL FAULT – Observed in outcrop, showing dip

ANTICLINE – Approximately located. Showing direction of plunge

PLANAR FEATURES

Coexisting features intersect at point of observation

STRIKE AND DIP OF BEDS
- 15 Inclined
- 55 Overturned
- 60 Crumpled beds – Showing approximate strike and dip

STRIKE AND DIP OF SCHISTOSITY – Commonly in rocks where bedding cannot be recognized
- 55 Inclined
- Vertical

STRIKE AND DIP OF PARALLEL BEDDING AND SCHISTOSITY
- 44 Inclined
- 68 Overturned

70 STRIKE AND DIP OF SCHISTOSITY OBSERVED TO BE PARALLEL TO AXIAL SURFACE OF SMALL FOLDS

STRIKE AND DIP OF JOINTS
- 76 Inclined
- Vertical

LINEAR FEATURES

May be combined with symbols for planar features

BEARING AND PLUNGE OF AXES OF CRINKLES OR MINOR FOLDS
- Plunging
- Horizontal

BEARING AND PLUNGE OF MINERAL LINEATION

RELICT SEDIMENTARY FEATURES – Used to determine top-facing directions in pre-Triassic rocks
- Graded beds
- Crossbedding
- Small channels or truncations

INTRODUCTION

The eastern two-thirds of the Southwick quadrangle is a lowland underlain mostly by the New Haven Arkose of Triassic age, a sequence of dominantly reddish-brown arkosic siltstone, sandstone, and conglomerate. These rocks have been intruded by a small fine-grained medium-greenish-gray, presumably dikelike, diabase body of Triassic age in the southeast corner of the quadrangle. This body is probably a small apophysis from a much larger body exposed on Manitock Mountain just to the south in the Tariffville quadrangle (Schnabel and Eric, 1965).

The western one-third of the quadrangle is an upland underlain by a dome or anticline of high-grade schists and gneisses of probable Ordovician age that have been intruded by abundant pegmatites of probable Devonian age and sparsely intruded by ultramafic bodies of probable Ordovician age.

Much of the quadrangle is covered by a thick accumulation of unconsolidated Quaternary deposits (Schnabel, 1971); less than 5 percent of the area has bedrock exposed at the surface, and most of these bedrock exposures are in the uplands. Although distinctive lithologies are present in the lowlands, outcrops are too few and too widely spaced to permit separation of units within the New Haven Arkose. Distinctive lithologies are mapped in the uplands; but several rock types are commonly included within a given map unit either because the individual types are too thin to be mapped on the scale chosen, or because they do not persist for long distances along strike.

CORRELATION OF MAP UNITS

Correlation of the pre-Triassic units in the Southwick quadrangle with units established to the north and south in Massachusetts and Connecticut is based in part on stratigraphic sequence and in part on lithologic similarity (see correlation chart). Correlation with units mapped in the Collinsville quadrangle (Stanley, 1964) is based on continuous mapping between the Collinsville and Southwick quadrangles (Schnabel and Eric, 1965; and unpublished mapping by Schnabel in New Hartford and West Granville quadrangles). The principal map unit that has been traced from the Collinsville quadrangle is the Straits Schist, which is a distinctive rusty schist that is overlain by a thin calc-silicate unit, that is in turn overlain by a thick nonrusty aluminous unit. The Straits Schist is underlain by a sequence of volcanic rocks, mostly amphibolites, in the Southwick quadrangle. A similar sequence of deposition was recognized in the Collinsville quadrangle (Stanley, 1964).

Correlations with units mapped in Massachusetts and Vermont are more tenuous because detailed mapping is not yet available for intervening areas. It would appear that the Hartland Formation, the Straits Schist, and the Collinsville Formation are probably equivalent to the unit mapped to the north as the Hawley Formation; most of the other units mapped to the north are not present in the Southwick quadrangle. The Moretown Formation and the Rowe Schist of north-central Massachusetts (Hatch, 1969) presumably underlie the formations exposed in the center of the dome; the Goshen Formation overlies the Hawley Formation and presumably has been removed by erosion. Because many of the units mapped in the Southwick quadrangle are apparently absent from the better known section to the north and west, names commonly used in reports describing the geology of Connecticut have been used here.

A difficulty in the correlation presented here is that the Hawley Formation in the Worthington quadrangle (Hatch, 1969) is about 2,500 feet thick and consists of amphibolite, metavolcanic rock, calcareous schist, carbonaceous schist, and sparse coticule; whereas the Hartland, Collinsville, and Straits aggregate almost 15,000 feet as a minimum thickness and consist of much thicker bodies of schist overlying amphibolite, schist, and metavolcanic rocks. This increase in thickness may be explained by the fact that the Hawley Formation is unconformably overlain by the Goshen Formation, and in areas to the west and north erosion below this unconformity may well have removed rocks still present in the Southwick quadrangle. An alternative explanation is that rocks present in the Southwick quadrangle were not deposited to the north and west.

All correlations are based on the fact that the sedimentary structures mapped in the units in the western third of the Southwick quadrangle indicate a normal succession of units, and that these units form a simple dome. Many measurements of original sedimentary structures such as crossbedding, graded bedding, and channel structures show that the units face outward from the dome, and the preservation of these structures implies that the rocks have not undergone severe deformation. Other interpretations of correlations of rock units in the Southwick area (Hatch and Stanley, 1970; Stanley, 1968) are based primarily on a lithologic similarity between parts of the Goshen Formation and parts of the Straits Schist. These correlations require complicated structures that (a) do not show symmetry, and (b) are not supported by tops-of-beds information derived from sedimentary structures observed during mapping the Southwick quadrangle.

No direct information is available on the age of the units mapped in the Southwick quadrangle. No fossils were found, nor have any radiometric age determinations been made. The age designations given on the explanation are extrapolations based on the assumption that correlations as here given are correct.

STRUCTURAL GEOLOGY

The Southwick quadrangle is divided into two parts by a north-striking, anastomosing normal fault downthrown on the east. The eastern two-thirds is apparently a simple homocline dipping to the east at 15° to 20°; the western third is part of a doubly plunging anticline or dome elongated along a north-trending major axis.

The structure in the eastern two-thirds of the quadrangle may be much more complicated than suggested by cross section A-A' because strikes and dips are variable. Similar divergences from a simple monocline have been noted elsewhere (Schnabel and Eric, 1964; Schnabel and Eric, 1965; Wheeler, 1937) and have been commonly interpreted as minor monoclinal structures superimposed on the generally eastward dipping homocline. In yet other, better exposed areas in the Triassic basin (Hanshaw, 1968; Rodgers and others, 1959) normal faults are very numerous. Such faulting may exist in the eastern part of the Southwick quadrangle and be an explanation for the anomalous dips and strikes. No faults or brecciated zones were observed in any of the exposures seen in the Triassic rocks, however.

The dome exposed in the western third of the quadrangle and another small dome exposed to the southwest in the New Hartford quadrangle were called the Granby domes by Rodgers and others (1959); this dome is here called the North Granby dome. The northern end of the dome closes on the Straits Schist in the Southwick quadrangle; the southern end closes on the Straits Schist in the Tariffville quadrangle (Schnabel and Eric, 1965).

inor folds of relatively small amplitude are common in many exposures around the North Granby dome, but they are most abundant in exposures around the northern end. The minor folds fall into three ages: (1) irregular, asymmetrical folds created during the intrusion of pegmatities–(youngest), (2) drag folds related to the domal uplift, and (3) folds with axial plane foliation that may have formed prior to the domal uplift.

The irregular, asymmetrical folds often show several directions of plunge in a single outcrop and range from open, gentle flexures to tight, nearly isoclinal folds. Commonly these folds follow the contours of small pegmatite bodies that abound throughout the quadrangle, and they appear to have formed during the intrusion of those bodies.

Drag folds associated with the domal uplift have plunges essentially parallel to the plunges of the part of the dome on which they are located, and they can be used to determine top-facing directions according to the methods described by Billings (1950, p. 76). In some places, however, these folds have been distorted by the later folds produced during pegmatite intrusion, and so they give somewhat erratic results when compared with top-facing directions shown by primary sedimentary structures. Where uncontorted by later folds, they give results comparable to those shown by the sedimentary structures.

Folds with axial plane foliation were observed only in the quartzo-feldspathic unit of the Hartland Formation (Ohqf) on the northeast flank of the North Granby dome. Folds with axial plane foliation were not observed in rocks of similar composition elsewhere in the quadrangle.

Nearly all of the large, fresh, manmade exposures in the western one-third of the quadrangle show minor, normal faults. Similar faults were not observed in natural outcrops. Faults with sufficient displacement to require offset of map units were not observed in the western third of the quadrangle.

The only major fault in the quadrangle is the long north-trending normal fault that separates the Triassic rocks on the east from the pre-Triassic rocks on the west. This fault is nowhere exposed in the Southwick quadrangle; its position is inferred from the east-facing scarp along the pre-Triassic crystalline highlands. The total displacement on this fault is unknown. A minimum of 100 feet is required near the south end of the quadrangle between the Triassic exposures on Dismal Brook and the pre-Triassic exposures on Crag Mountain, using interpretive techniques suggested by Wheeler (1937). Geophysical techniques or drilling would be required to determine the maximum displacement.

West of the intersection of Cline Road and Loomis Street, and also west of Mundale, crystalline rocks are exposed east of the trace of the main fault. In both places, the fault trace through the crystalline rocks is marked by a sharply incised valley and by differing attitudes in the crystalline rocks on the sides of the valley. East of these places, the contact between the crystalline and Triassic rocks is defined by a scarp formed on the crystalline rocks. Because outcrops were not found close to these eastern fault segments, it has not been possible to map them accurately; the curved lines represent the approximate boundary of the crystalline rocks.

Well-developed systematic joint systems are not commonly exposed in the Southwick quadrangle. The schistose rocks are relatively unfractured, and existing joints are commonly irregular and widely spaced. Most well-developed joint patterns were observed in the denser, more homogeneous rocks such as pegmatities and amphibolites. The joints plotted in the pre-Triassic rocks show an indistinct radial pattern and an equally indistinct concentric pattern around the North Granby dome. According to Wisser (1960) such a fracture pattern suggests that the structure containing it formed by differential vertical movements produced by forces directed vertically.

METAMORPHISM

The Triassic rocks are unmetamorphosed except for possible contact metamorphism adjacent to the small diabase body in the southeast corner of the quadrangle. No metamorphic or hydrothermal effects were observed in rocks near the Triassic faults. The pre-Triassic rocks are nearly all sillimanite-bearing where their composition is appropriate.

AEROMAGNETIC CORRELATIONS

The pattern of contours on the aeromagnetic map (Boynton and others, 1965) reflects nearly directly the distribution of map units over most of the quadrangle. The aeromagnetic high south of Cooley Lake is directly over an area in which no bedrock is exposed. The till in this area, however, contains angular fragments of fine-grained light-pinkish-gray coticule with abundant crystals of magnetite as much as ¼ inch in diameter. Presumably this rock is below the till and is responsible for the aeromagnetic high.

In the northwest corner of the quadrangle, a northeast-trending magnetic low trends across the strike of the units mapped. No reason for this low appears in the surface exposures; it may represent the magnetic expression of rocks at depth.

MINERAL RESOURCES

Metallic and nonmetallic mineral deposits of economic importance under 1970 conditions were not observed in the bedrock formations of the Southwick quadrangle. The principal economic resources are the sand and gravel deposits (Schnabel, 1971).

Local areas within the kyanite-sillimanite schist unit of the Hartland Formation contain potentially recoverable concentrations of kyanite or sillimanite, particularly on the uplands north of The Gorge on the Little River. Tonnages are difficult to estimate; perhaps 3,000,000 tons of 30 percent ore might be produced from near-surface exposures.

Pegmatite bodies within the quadrangle represent a minor potential resource of feldspar and scrap mica. Most bodies are too small to warrant exploitation and, except for a trace of beryl in one body, no other commercially important minerals were noted.

Some of the bedrock units might be exploited as sources of building stone. In the past, many of the rock types, especially the Triassic sandstones, have been used as dimension stone. Some of the bedrock units might find use as decorative materials.

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CORRELATION OF ROCK UNITS

AGE[1]	Worthington quadrangle Massachusetts (Hatch, 1969)
	Not exposed
EARLY OR MIDDLE(?) DEVONIAN	Granite, pegmatite, and quartz
MIDDLE AND LATE SILURIAN TO EARLY DEVONIAN	Goshen Formation
	UNCONFORMITY
LATE ORDOVICIAN	Ultramafic rocks undivided
MIDDLE ORDOVICIAN	Hawley Formation
MIDDLE ORDOVICIAN	Moretown Formation
EARLY TO LATE CAMBRIAN AND EARLY ORDOVICIAN	Rowe Schist
EARLY CAMBRIAN	Hoosac Formation

AGE[1]	Southwick quadrangle Massachusetts-Connecticut (This report)	
LATE TRIASSIC	Newark Group	Diabase
LATE TRIASSIC	Newark Group	New Haven Arkose
	UNCONFORMITY	
DEVONIAN(?)	Pegmatite	
	Not exposed	
LATE ORDOVICIAN	Ultramafic rocks	
MIDDLE AND LATE ORDOVICIAN	Hartland Group	Garnet schist
MIDDLE AND LATE ORDOVICIAN	Hartland Group	Kyanite-sillimanite schist
MIDDLE AND LATE ORDOVICIAN	Hartland Group	Quartz-plagioclase mica schist
MIDDLE AND LATE ORDOVICIAN	Hartland Group	Rusty mica schist
MIDDLE AND LATE ORDOVICIAN	Hartland Group	Calc-silicate zone
MIDDLE AND LATE ORDOVICIAN	Straits Schist	Upper schist
MIDDLE AND LATE ORDOVICIAN	Straits Schist	Zoisite zone
MIDDLE AND LATE ORDOVICIAN	Collinsville Formation of Stanley (1964)	Coticule zone
MIDDLE AND LATE ORDOVICIAN	Collinsville Formation of Stanley (1964)	Heterogeneous sequence
	Not exposed	

AGE[1]	Collinsville quadrangle Connecticut (Stanley, 1964)[2]		
TRIASSIC	New Haven Arkose	Dolerite	
	UNCONFORMITY		
PRE-TRIASSIC	Granitic rocks		
PRE-TRIASSIC	Not exposed		
PRE-TRIASSIC	Hartland Group	Slasher's Ledges Formation	Rusty schist member
PRE-TRIASSIC	Hartland Group	Slasher's Ledges Formation	Ultramafic rocks
PRE-TRIASSIC	Hartland Group	Slasher's Ledges Formation	Kyanite schist member
PRE-TRIASSIC	Hartland Group	Satan's Kingdom Formation	Breezy Hill Member
PRE-TRIASSIC	Hartland Group	Satan's Kingdom Formation	Ratlum Mountain Member
PRE-TRIASSIC	Hartland Group	Rattlesnake Hill Formation	Upper member
PRE-TRIASSIC	Hartland Group	Rattlesnake Hill Formation	Lower member
PRE-TRIASSIC	Hartland Group	Rocks on Jones and Yellow Mountains[3]	
PRE-TRIASSIC	Hartland Group	The Straits Schist	
PRE-TRIASSIC	Lower group	Collinsville Formation	Sweetheart Mountain Member
PRE-TRIASSIC	Lower group	Collinsville Formation	Bristol Member
PRE-TRIASSIC	Lower group	Taine Mountain Formation	Whigville Member
PRE-TRIASSIC	Lower group	Taine Mountain Formation	Scranton Mountain Member
PRE-TRIASSIC	Lower group	Taine Mountain Formation	Wildcat Member
	Not exposed		

[1] Age designations are those used in report cited.
[2] Stratigraphic sequence in the Collinsville quadrangle has been revised by Stanley (1968) and by Hatch and Stanley (1970). (See text).
[3] "Rocks on Jones and Yellow Mountains" are here considered to be equivalent to the Taine Mountain Formation and are probably older than the Hartland Formation.